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Comparison of ultrasound-guided single vs bi-level erector spinae plane block for postoperative pain in benign thoracotomy operations

Singel and Bi-level injection comparison in erector spinae plane block

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Abstract
Aim: Chronic postoperative pain may develop in more than half of patients after thoracotomy. Studies have shown that the Erector Spinae Plane Block is both an effective and safe analgesia method for thoracotomy. This study aims to investigate the effect of 10 ml 0.5% bupivacaine on postoperative pain in two doses divided from T4-T6 level with a single dose of 20 ml 0.5% bupivacaine from T5 level.
Material and Method: Sixty-three patients aged 20-55 years who underwent thoracotomy were included in the study. The patients were divided into two groups as single-level (Group S, n: 32) and bi-level (Group B, n: 31). Pain scores, intraoperative remifentanil, and postoperative 24-hour morphine consumption were recorded at postoperative hours 1, 6, 12, and 24.
Results: Postoperative visual analog pain scores were significantly lower ($p<0.001$) at 1, 6, and 12 hours in single-level block patients. There was a significant decrease in intraoperative remifentanil consumption and postoperative 24-hour morphine consumption in the single-level block group ($p<0.001$).
Discussion: It was concluded that 20 ml 0.5% bupivacaine with a single injection provided lower pain scores and decreased the need for additional morphine during the postoperative 24 hours.

Keywords
Nerve block; Thoracotomy; Postoperative pain; Opioid

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Introduction

Chronic postoperative pain may develop in 25-60% of patients after thoracotomy [1]. Thoracic epidural analgesia and paravertebral block are commonly used to relieve post-thoracotomy pain after thoracic surgery [2,3]. However, the failure and complication rates are high since these techniques are difficult to perform [4,5]. Erector spinae plane block (ESPB) is preferred because it is easy to apply in patients undergoing thoracic surgery and provides safe and effective analgesia [6-8]. Clearer visualization of anatomical structures has increased the popularity of ESPB with advances in ultrasound technology in recent years. Single and multiple injection techniques have been used in ESPB applications in the literature [9,10]. In this current study, we thought that the patient comfort would increase, and the complication rate would decrease with single-level injection, and local anesthetic distribution would be more reliable in bi-level injections. Thus, this study aims to compare the effect of two different injection techniques on postoperative analgesia.

Material and Methods

The study was conducted in the thoracic surgery operating room of KTU Farabi Hospital after obtaining approval from the local ethics committee (2017-588) for our randomized controlled, observer-blind study. Our study was conducted between December 2017 and January 2020 in 63 patients aged 20-55 years who were scheduled for posterolateral thoracotomy (lobectomy, but without chest wall resection and pneumonectomy) at the level of T5-T6. Exclusion criteria for patients were: age ≤20 or ≥55 years, body mass index (BMI) >30 or ≤18 kg/m2, skin infection at the ESPB site, any known allergies, pre-existing pain syndromes, patients with pregnancy, malignancy, severe liver disorders, kidney disorders (serum creatinine greater than 2 mg/dL, oliguria, anuria or hemodialysis), or cardiovascular disorders.

During the preoperative visit, patients were informed about the postoperative visual analog scale (VAS) used to assess pain scores and the use of the patient-controlled analgesia (PCA) device. The patients were divided into two groups as single-level of ESPB (Group S) or bi-level of ESPB (Group B) with computer-generated randomization. The study design is shown as a consort diagram in Figure 1.

In the regional block application room, patients were noninvasively monitored with a pulse oximeter, continuous arterial blood pressure, and an electrocardiogram. ESPB was performed in the sitting position. The same ultrasound device (Mindray Diagnostic Ultrasound System, DC-T6, Shenzhen, China) and 10 MHz ultrasound probe, and 21 G, 100 mm block needle (Stimuplex® A, B.Braun, Melsungen AG, Germany) were used in all blocks. Single-level block applications were performed with 20 ml 0.5% bupivacaine at the T5 level, and bi-level applications were performed at the levels of T4 and T6, 10 ml 0.5% bupivacaine each.

The probe was moved downwards to detect the T5 spinous process, and the probe was positioned 2 cm laterally to the spinous process after the detection of the C7 spinous protrusion by palpation in Group S. The trapezius muscle, rhomboideus major muscle, and erector spinae muscles were visualized from the outside to the inside. The needle was advanced in the craniocaudal direction towards the midpoint of the T5 transverse process using the in-plane technique after providing a clear ultrasound image of the pleura and T5 transverse process. After 0-5-1 ml saline injection, the local anesthetic mixture was injected into the target point to confirm the needle position. The same procedures were performed separately by dividing the local anesthetic dose from both T4 and T6 levels in Group B. The sensory block was performed with unilateral cold application in the 6th intercostal area in the midaxillary line. Patients without a sensory block at the end of 30 minutes were excluded from the study.

All patients received 1.5-2.0 mg/kg of intravenous propofol, and 1 μg/kg fentanyl to induce general anesthesia. Neuromuscular block was obtained with 0.6 mg/kg of intravenous rocuronium. The placement of the double-lumen endotracheal tube was confirmed with a fiberoptic bronchoscope. All patients were monitored with the bispectral index to ensure a level of 40-60. Anesthesia was maintained with sevoflurane and 0.05–0.5 μg/kg/min of intravenous remifentanil infusion. A 25 μg remifentanil bolus dose was administered, and the infusion dose was increased in case of a 20% increase in blood pressure compared to baseline and a 20% difference in heart rate despite appropriate fluid resuscitation. All patients underwent a 15-20 cm long incision and excision of the serratus anterior, latissimus dorsi, and intercostal muscles. All patients underwent chest tube insertion through the T8 intercostal space. Patients received intravenous doses of 1 g paracetamol and 100 mg tramadol for postoperative analgesia approximately 30 minutes before the end of surgery.

At the end of the surgery, all patients were extubated and transferred to the ICU. Patient-controlled analgesia was applied to all patients in the intensive care unit with a PCA device containing morphine with the following settings: 1 mg bolus for 8 minutes, and 0.5 mg/ml continuous infusion, a limit of 6 mg per hour. PCA was terminated when side effects such as SPO2 <95%, respiratory rate <10/min, development of sedation (Ramsay sedation scale >2), allergy, itching, vomiting, and a decrease in systolic blood pressure of more than 20% occurred. Tramadol was administered intravenously for rescue pain if VAS > 3 despite PCA.

Demographic data, duration of operation and anesthesia, intraoperative remifentanil consumption were recorded. Patients were asked to score pain their levels at the 1st, 6th, 12th, and 24th hours using the VAS after surgery. The total demand times of PCA were read from PCA memory and the 24-hour morphine consumption, morphine-related side effects (nausea, vomiting, itching, and respiratory depression) and the amount of tramadol were recorded.

Statistical Analysis:

The total number of samples was calculated as 52 (Type 1 error=0.05, type 2 error=0.20, and effect size=0.7) based on the study conducted by Gürkan Y. et al. [11]. It was decided to include approximately 63 patients in the study, considering possible data losses (20%). Descriptive statistics were given as mean±standard deviation and number(frequency%). For intergroup comparisons, the Mann-Whitney U test and the Chi-square tests were used. A p- value <0.05 was considered significant.

Results

The study involved a total of 66 patients in Group B (n=34) and Group S (n=32). One patient in Group B and 2 patients in Group S were excluded from the study because the sensory block did not reach the T5 level. Demographic data are shown in Figure 1. Intraoperative remifentanil consumption was significantly lower (p< 0.001) in Group S (515±63.8 µg) compared to Group B (588±64 µg). Postoperative VAS scores were significantly lower (p<0.01) at 1st, 6th, and 12th hours in Group S (Table 3). In addition, 24-hour morphine consumption in Group S (5.84±1.24 mg) was significantly lower (p<0.001) compared with Group B (8.66 ±1.35 mg). Nausea-vomiting occurred in 9 patients (28.1%) in Group S and 13 patients (40.6%) in Group B and was significantly different (p=0.03). The amount of rescue analgesic tramadol was similar between groups (p>0.05, Table 2).

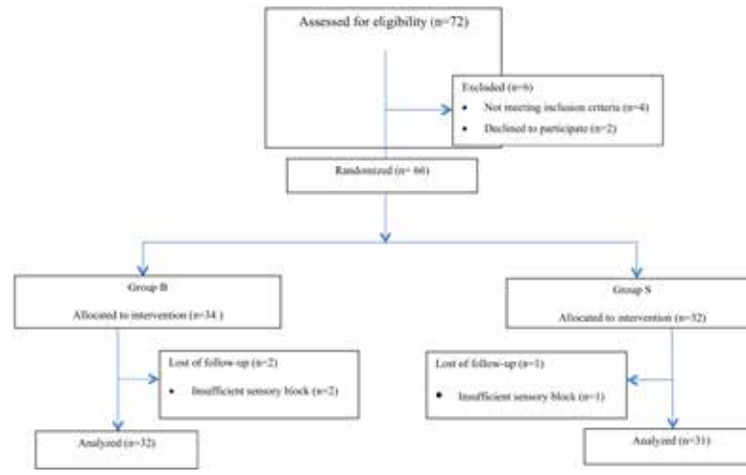

Figure 1. CONSORT study flow diagram.

Table 1. Patient characteristics

Group	Group S (n=31)	Group B (n=32)	p value
Age (year)	34,6± 8,5	33± 8	0,378
Sex (male /female)	22/9	23/9	0,937
ASA 1/2	14/17	15/17	0,892
Weight (kg)	68,3± 9,27	68,4± 11,07	0,863
Height (cm)	168,6± 9,9	169,4± 11	0,767
BMI (kg/m²)	23,78± 3,26	24,81± 2,32	0,262
Duration of surgery (min)	104,1± 112,6	103,2± 15,8	0,757
Duration of anesthesia (min)	141,6± 10,7	141,9± 13,1	0,799

Group S: Single-level Group B: Bi-level
Data are shown as mean ± SD or numbers (%)
BMI: (Body Mass Index) ASA: American Society of Anesthesiologist

Table 2. Analgesic data and opioid-related adverse events

Group	Group S (n=31)	Group B (n=32)	p value
Intraoperative remifentanil consumption (µg)	515± 63,8	588± 64	< 0,001
Postoperative morphine consumption (mg)	5,84± 1,24	8,66± 1,35	< 0,001
Nausea and vomiting	9(28,1%)	13(40,6)	0,03
Respiratory depression	0	0	-
Pruritis	0	0	-
Number of patients requesting tramadol	5(15,6%)	9 (29%)	0,2

Group S: Single-level Group B: Bi-level
Data are shown as mean ± SD or numbers (%)

Table 3. Postoperative VAS scores

Postoperative VAS score	Group S (n=31)	Group B (n=32)	p value
VAS 1. hour	2,29± 0,64	3,22± 0,65	< 0,001
VAS 6. hour	2,71± 0,73	3,41± 0,83	0,002
VAS 12. hour	2,84± 0,58	3,41± 0,71	0,001
VAS 24. hour	3,10± 0,83	3,47± 0,8	0,11

VAS: Visual Analog Scale
Group S: Single-level Group B: Bi-level; Data are shown as mean ± SD

Discussion

Erector spinae plane block is a new regional analgesia technique that has recently begun to be applied. The erector spinae plane is located between the erector spinae muscle and the transverse process. Local anesthetic, injected into this plane, spreads to the paravertebral area, intervertebral area, dorsal and ventral rami of thoracic spinal nerves [12]. Thus, it affects the retrolaminar and paravertebral block areas in this way [13]. The likelihood of damage to the neuraxial structures, pleura, and major vascular structures is very low since transverse processes can be seen on USG and anatomical signs are prominent. ESPB using USG has been reported to be a safer alternative to thoracic epidural and paravertebral block [6, 14].

This current study showed that patients with single-level ESPB had better pain scores after thoracotomy surgery. In addition, morphine consumption during the postoperative 24-hour period was less when a single-level block was performed.

ESPB is important in providing adequate analgesia of the nerve block, the dose of the local anesthetic, the region where it is applied and its spread, as with all interfascial plane blocks. There are conflicting results regarding the optimal dose of local anesthetic and the mechanism of action of ESPB. It was stated that ESPB may provide visceral analgesia through spreading to the anterior direction along the paravertebral area and by passing to the ventral and dorsal rami [14-16]. Examination of cadavers showed that injection of 20 ml of normal saline and methylene blue to the erector spinae plane at the T5 level spread 5 levels in the craniocaudal direction, but the spread to neural foraminal and epidural spaces was limited to 2-3 levels [16]. Another cadaver study using 10 ml of distilled water, latex and green ink at the same injection site reported no spread to the paravertebral area and only 2 levels of craniocaudal spread [17]. In contrast, a case report showed spread of local anesthetic to the paravertebral area and epidural space following ESPB using 20 ml of local anesthetic at the T5 level, resulting in sensory block at level of T4-T7 and sufficient visceral analgesia [18]. Another case report showed T2-T7 level dermatomal analgesia and paravertebral and neural foraminal spread on computerized tomography with 25 ml of local anesthetic applied at the T5 level with ESPB [19]. In accordance with the clinical and cadaver studies mentioned above, we thought that pain scores were

good and opioid consumption was low, since both paravertebral and craniocaudal spread of 20 ml of local anesthetic was sufficient in our study. Consistent with the study by Choi et al, the higher pain scores and morphine consumption in our study may be due to inadequate spread with 10 ml of local anesthetic [17].

Tulgar et al. [9] compared the effect of two-dose ESPB at bi-level on pain scores, intraoperative, and postoperative opioid consumption of single-dose ESPB at single level in thoracotomy cases in a study similar to our study. They found better pain scores and less opioid consumption with bi-level injections. However, they used a higher volume (30 ml) of local anesthetic compared with our study. Sufficient spread may have occurred with bi-level application since a high volume of local anesthetic is used. In contrast to the study by Tulgar et al., we used a lower volume with a higher concentration.

Patients who underwent thoracotomy surgery for non-cancer etiologies were included in our study, unlike the studies conducted in the literature using ESPB in thoracotomy surgery. Thus, it was ensured that the existing cancer-related pain did not affect postoperative pain scores and other frequency of side effects.

Conclusion:

We have concluded that the use of 20 ml 0.5% bupivacaine with a single level injection provides better postoperative analgesia compared with bi-level block.

Limitation:

There were several limitations in our study. First, it is known that the rate of local anesthetic injection affects the spread in the neuraxial area and the number of dermatomes it forms the block. However, we did not include this parameter in our study. Secondly, we could not support the spread of the local anesthetic dose administered with two different methods using imaging techniques.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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